Responding to Sea Level Rise: Does Short-term Risk Reduction Inhibit Successful Long-term Adaptation?

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Key Points:

- Existing policy and planning processes bias against and delay decisions to take aggressive, proactive actions to adapt to sea level rise.
- Future policy should weaken the positive feedback between risk reduction and real estate market responses.
- Future policy should emphasize adaptive engineering and planning practices that judiciously consider the needs of the region and nation.

Abstract

Most existing coastal climate-adaptation planning processes, and the research supporting them, tightly focus on how to use land use planning, policy tools, and infrastructure spending to reduce risks from rising seas and changing storm conditions. While central to community response to sea level rise, we argue that the exclusive nature of this focus biases against and delays decisions to take more discontinuous, yet proactive, actions to adapt–e.g., relocation and aggressive individual protection investments. Public policies should anticipate real estate market responses to risk reduction to avoid large costs–social and financial–when and if sea level rise and other climate-related factors elevate the risks to such high levels that discontinuous responses become the least bad alternative.

1 Introduction

Increasing and overwhelming consensus about the reality of accelerating rates of sea level rise (SLR) (Kopp, et. al. 2017; Intergovernmental Panel on Climate Change, 2013), combined with devastating damage from extreme storm events has led to heightened interest in managing risk to the built environment. Risks, and attention to those risks, have been increasing in both developed and developing nations. This has been particularly true in the U.S. Atlantic and Gulf coasts (Smith & Katz, 2013), where more than forty communities have produced adaptation plans in the past decade (Woodruff & Stults, 2016). These efforts have been geared toward reducing risk through "climate-proofing" the infrastructure. We argue in this article that these policies have already and likely will continue to exacerbate the negative consequences of positive feedbacks in coastal real estate markets in the US—and are likely to exacerbate the negative consequences of positive feedbacks in other coastal real estate markets worldwide as these regions simultaneously continue to grow and begin to address the looming threat of sea level rise. Namely, these policies risk systematically biasing adaptation actions away from discontinuous responses by individuals and businesses that reduce vulnerability to those that accelerate vulnerability. We suggest three feasible remedies: policies that weaken this positive feedback, adaptive engineering that provides transparent time paths for risk, and planning practices with a regional (county, state) or national lens that explicitly consider the timing and management of relocation/migration.

Sea level is unequivocally rising and human-occupied barrier islands and other low lying coastal settlements, such as those along the U.S. Atlantic and Gulf Coasts, will become uninhabitable at a point in the future with very high probability (Hauer et al., 2016). Relocation from these communities then becomes a question of "when" and not "if." Public policies, weather events, and market forces will combine to determine the salient variables in this transition–loss of property, extent of social and economic disruption, and environmental damage caused by abandoning previously populated areas.

The positive feedback loop results from the interplay of planning/policy decisions and market responses. Public investments in various forms of risk-reducing "climate-proofing" lower the risks from climate-driven events. Real estate markets condition their investments on this reduced risk, building both higher value structures and choosing locations and construction techniques that are more vulnerable to damage than would be the case if they faced higher risk. The inflated value of coastal homes then justifies more investment in "climate-proofing" and the cycle continues. Our argument in this paper is not that public investment in risk reduction is a bad idea; it is that such investments should be made with full understanding of this positive feedback, and that ancillary policies should address ways to weaken the positive feedback, thereby reflecting the true underlying risk due to an inevitable loss of habitability in these locations.

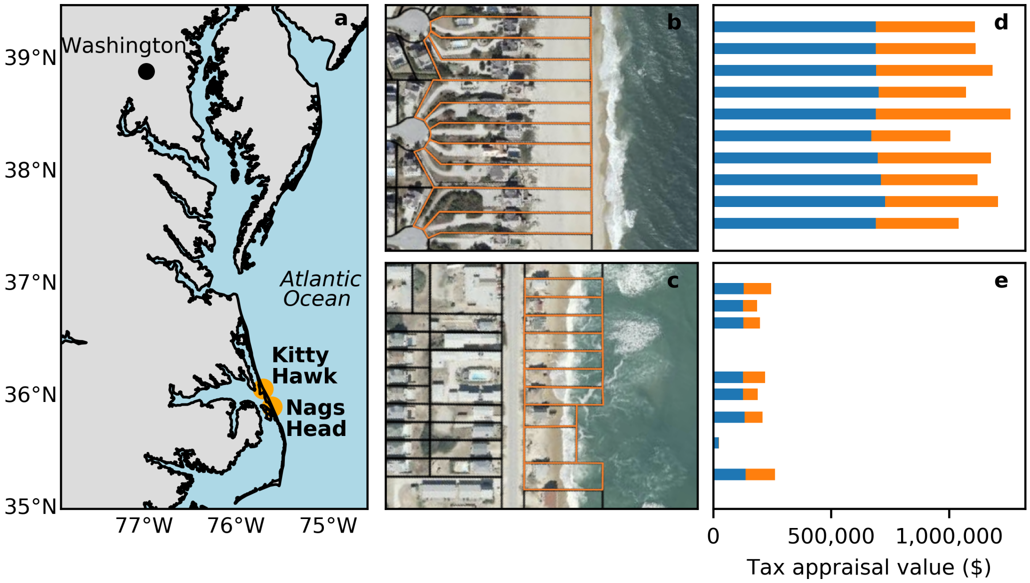

Figure 1. Illustrative example of the negative consequences of positive feedback, as the real estate market responds to risk reduction, based on two nearby beachfront communities in North Carolina's Outer Banks, USA (a). Pane (b) shows a section of beach in Nags Head, NC that has been nourished to provide storm and erosion protection, while pane (d) shows the tax appraisal value by beachfront property for land (blue) and homes (orange); the average assessed value of beachfront properties in pane (b) is $1.15 million. Pane (c) shows a section of beach in Kitty Hawk, NC, about 20 km north of the Nags Head beach shown in pane (b), while pane (e) shows the tax appraisal value in Kitty Hawk by beachfront property for land (blue) and homes (orange). This Kitty Hawk beach has not been nourished and has eroded to the point that the homes are at risk of storm damage and condemnation. The average assessed value of beachfront properties with homes in pane (c) is $217,000; if the three un-buildable lots (due to erosion) shown in pane (c) are included, then the average assessed value is $152,000.

A clear illustration is given by coastal engineering projects specifically to reduce risk in beach communities (hereafter shoreline engineering)—moving sand from offshore locations to the beach, constructing hard structures (e.g., seawalls, groins), or a combination – to protect coastal real estate from erosion and storm-driven damage (Nordstrom, 2004; Gopalakrishnan et al., 2011; Armstrong et al., 2016). This reduces erosion and flood risk to buildings and other structures close to the beach, which in turn encourages more expensive construction and addition to the stock of beachfront housing. The positive feedback comes into play when the time comes for replenishment or maintenance of shoreline engineering—the higher the value of at-risk real estate, the stronger the economic case and political pressure for another round of engineering intervention. This feeds back to more shoreline real estate investment, and the cycle repeats. Figure 1 provides an illustrative example of the negative consequences of this positive feedback, where the combination of risk reduction measures in a Nags Head, NC community and lack of risk reduction measures in a nearby Kitty Hawk, NC community have led to an order-of-magnitude difference in average property values.

If this were a system of stable risks and purely local financing, then some sort of equilibrium would likely emerge to reflect tradeoffs between the cost of engineering measures and the returns to coastal real estate. This system is fundamentally not stable because of the accelerating risks of damage due to SLR and (probabilistically) more severe storms (Knutson et al., 2010). It is also likely that the cost of beach nourishment will increase dramatically due to increasing energy costs and scarcity and competition for sand resources (Peduzzi, 2014). While direct financing of engineering from non-local government entities has decreased, both shoreline engineering and shoreline property continue to enjoy subsidies/external transfers that continue to make beach nourishment a more attractive investment (McNamara et al., 2015).

The above discussion had focused on experience in the US Atlantic coast, but we believe the dynamics we identify will influence choices wherever there are coastlines vulnerable to SLR as more communities engage in risk-reducing engineering to protect physical capital. For example, Australia has large numbers of nourishment projects that are concentrated near urban areas with high value real estate (Cooke et al 2012). Ghana (Fagotto 2016) and the Marshall Islands (Milman and Ryan 2016) are examples of where risk-reducing engineering is already interacting with private decisions about the stock of built capital in developing countries.

At some point in the future the risks will be so high, and the cost of shoreline engineering so large, that such interventions will no longer be feasible and spontaneous abandonment/relocation will occur with significant, negative economic consequences to the region. The exact moment in time when this occurs is not known, but it is highly probable that it will take place following a severe event, such as a tropical cyclone or tsunami, where significant damage to the built environment and/or protective infrastructure will cause a discontinuity in the costs and benefits of outmigration. In any case, the continued focus on short-term policy, and inherent feedbacks between coastal hazard mitigation and coastal economics, will strongly effect when the tipping point towards uninhabitable coastal towns is crossed. This spontaneous abandonment will also influence what is at stake – socially, culturally, economically, and environmentally—when that tipping point is reached.

2 Implications for Policy

We advocate one specific direction for public policy as a response to this feedback dynamic, and another direction including two policies to better link short-term public decisions with longer-term outcomes. The first policy direction is to weaken the positive feedback between risk reduction and real estate market responses. Weakening the feedback should improve decision-making in both public risk-reduction policies and private real estate market responses. This requires that real estate developers and buyers not fully incorporate the current level of protection in long-lasting investments. Limiting the size and density of low-lying homes and buildings, mandating that new and remodeled construction be moveable, and transferring more of the financial responsibility for engineering expenses to at-risk property owners will all help in this regard. Information about the likely future property tax consequences of risk mitigation and infrastructure protection engineering would also help. Flood insurance has long been identified as a factor in effectively subsidizing at-risk property (Michel-Kerjan, 2010), but a wide range of current policies that subsidize rebuilding infrastructure and private property after disasters tend to enhance rather than inhibit this positive feedback, as does the generally favorable tax treatment of real estate investment relative to other economic opportunities.

We contend that elevating consideration of the positive feedback is particularly essential in the wake of weather-driven events like Hurricanes Harvey and Irma. Multiple levels of government are addressing both aid to rebuilding and new investments in climate-proofing, infrastructure hardening, and other projects to reduce risk from similar events. Explicit consideration of how these policies affect private real estate decisions is particularly critical because disasters offer a discontinuity in costs and benefits that make them key nodes for adaptation – when structures need major expenditures to return to productive use, the costs of rebuilding structures close to their pre-storm state become discontinuously greater relative to the costs of discontinuous change like relocation of these structures or abandoning them to move to less risky locations.

The second direction for policy we believe would be helpful is a greater emphasis on adaptive engineering strategies and large-scale planning practices that judiciously consider the needs of the region and nation—moving away from decisions made with a myopic focus on a specific beach town. Adaptive engineering strategies would aim to have future risk-reduction actions tied to longer-term observable climate variables, and mandate that such risk-reducing engineered interventions would be curtailed or sunset as those variables signal increased risk. In the beach nourishment example, this could mean a commitment to stop engineering when SLR reaches some pre-specified level using a specific SLR measurement protocol. Tying outcomes to an observable measure allows some built-in adaptive management—if risks increase more slowly than current predictions, protection will continue for a longer period; if more quickly, the opposite would occur. Such policies also offer a transparent information signal to private markets that becomes more certain as the target level of the variable gets closer to current conditions. While such policies are subject to the same time inconsistences as any long-term policy commitment, the fact that markets will start to use the information offers at least some built-in political support for not reversing those commitments as risks increase.

In addition to adaptive engineering, a regional or national view for coastal planning is essential in the prioritization of future coastal engineering investments and the timeline of adaptation measures. The coupled human-coastal response to climate risk can depend on the interaction between spatial patterns of physical coastline change and the spatial distribution of economic assets, with these patterns at larger scales than individual towns (McNamara et al., 2011). For example, when wealthier towns are facing larger erosion rates and pulling nourishment sand from a sediment resource that is shared with less wealthy towns, as the cost of beach nourishment rises due to increasing scarcity of sand, areas with high property value will gain preferential access to the sand resources as their higher property value justifies more expensive nourishment. This will leave lower property value areas to face looming destruction with no buffer or mechanism for a smooth relocation. It is critical to take these regional interactions between property value and engineering investment into account when managing coastal adaptation in order to prevent catastrophic changes in habitability befalling the least wealthy communities. Careful engagement of a wide range of communities is needed in the planning and selection of future engineering actions and relocation strategies.

The fundamental point of this article is that adaptation policy is not paying enough attention to the (almost) inevitable transition from living with risk to spontaneously relocating away from coastal areas. The dynamics of this transition, and the way that it affects social and economic outcomes for significant populations on low lying coastal margins across the globe—as well as the surrounding jurisdictions that would be strongly affected by disruptive transitions—are poorly understood. Given global trends that show both increasing coastal populations and more infrastructure that reduces short-term risk to the built environment, we expect the salience of this issue to become greater worldwide. Improving knowledge about the negative consequences of positive feedback between risk reduction and real estate investment is a key component of creating the knowledge necessary to make informed choices about the nature and timing of the way we adapt to rising seas and other climate-driven risks.

Acknowledgments, Samples, and Data

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